

# A RESUMÉ OF THE MEMBERS OF THE GENUS *CAMBARINCOLA* (ANNELIDA: BRANCHIOBDELLIDA) FROM THE PACIFIC DRAINAGE OF THE UNITED STATES

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*Abstract.*—There are eight known species of the branchiobdellid genus *Cambarincola* in the Pacific drainage of the United States. Of these *C. fallax* Hoffman, 1963, and *C. mesochoreus* Hoffman, 1963, are most probably introductions. *C. barbarae*, new species, may be, since its nearest relatives appear to be forms found in Mexico and the south-central portions of the United States and it occurs on introduced hosts. Two species, *C. gracilis* Robinson, 1954, and *C. macrocephelus* Goodnight, 1940 are extensively redescribed; they and the two new species (*C. barbarae*, *C. serratus*), are illustrated. *C. montanus* and *C. shoshone* are briefly treated. A key, synonymies, type-specimens, diagnoses, and locality data are presented for all species.

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Of the 42 nominal species of the branchiobdellid genus *Cambarincola* Ellis, 1912, four have been recorded as occurring in the Pacific drainage of the United States. Two of these require extensive redescriptions. In addition, I have at hand western specimens of two species previously known only from the eastern United States, and of two new species. As another in my series of reports on North American branchiobdellids I present herein a summary of the taxonomic knowledge of these species.

The first assignment of a western species to the genus *Cambarincola* begins with that of specimens from Eugene, Oregon, as the types of *C. inversa* Ellis, 1919:259. Altman (1936:71) assigned specimens from the same locality to Ellis's species. Goodnight (1939:11) reported the species as "Northwestern," later (1940a:70-71) listing new localities for it in Oregon and Washington. This species, however, belongs to *Sathorilus* Holt, 1968 and the first species that can now be placed in the genus was recognized and described by Goodnight (1940b:57) and assigned to his new genus *Triannulata*. Later this species (*montanus*) was redescribed and placed in the genus *Cambarincola* (Holt, 1974:67-70). Goodnight (1943:100), with minimal descriptive data, recognized *C. macrocephalus* which is redescribed herein. Robinson (1954) named *C. gracillis* and presented a reasonably good description thereof, but present information requires a new description which is also part of this report. With the publication of the diagnosis and

description of *C. shoshone* Hoffman, 1963, the list of western species came to an end. Since then there may possibly have been a few references to these species in compendia and other publications not devoted to the genus, but I know of none other than the emendation mentioned above.

In spite of the extensive additions in the last two decades to our knowledge of the genus *Cambarincola* in other regions, there are still too many undescribed species and too few geographical data to allow for any additional speculations about the history of the genus or its relationships with other genera (Holt, 1969, *inter alia*). The earlier speculations about close affinities of the eastern and western branchiobdellid faunas seem to be confirmed (Holt, 1968a:84). The presence in the West of two (*C. fallax*, *C. mesochoreus*), and possibly another (*C. barbarae*), eastern species on hosts that were likewise introduced suggests that a natural experiment in competition may be occurring between these species and their western and now sympatric relatives. The outcome of any such postulated competition will furnish data for the acceptance or rejection of my idea that the western crayfish fauna is relictual and by implication that the major brachiobdellid radiation occurred earlier than that of their principal hosts (Holt, 1969:215–216).

The western branchiobdellid fauna seems to be relatively depauperate:  $\frac{3}{4}$  as many species of *Cambarinocola* occur in Florida (Holt, 1973a, 1973c) as are known in all the vastly greater in extent and apparently more varied western region. The possibility that this appearance is an artifact of collecting cannot be ignored, but I doubt it.

The materials are in my possession, ultimately to become part of the collections of Virginia Polytechnic Institute and State University or those of the National Museum of Natural History. "PCH" followed by a numeral indicates the catalog number of collections in my care. All collections recorded under "Material examined" were taken by my wife and me, aided by our daughter, unless otherwise noted.

Measurements were done with a calibrated ocular micrometer, but are best regarded as approximations. Most measurements are presented as averages with the extremes in size of the object measured given in parentheses.

In all figures the animal, or part, is illustrated with its anterior part to the reader's right. Further details concerning my methods of collecting and treating materials may be found in my earlier works (Holt, 1960:57, 62–70, *et seq.*).

#### Genus *Cambarincola* Ellis, 1912

*Astacobdella* Leidy, 1851:206.

*Branchiobdella*.—Moore, 1894:427 (in part).

*Bdellodrilus*.—Pierantoni, 1912:24 (in part).

*Cambarincola* Ellis, 1912:481; 1919:25.—Hall, 1914:190.—Stephenson, 1930: 801.—Yamaguchi, 1932:454; 1933:191; 1934:189.—Goodnight, 1939:11; 1940a: 170–171; 1940b:30; 1943:100.—Holt and Hoffman, 1959:97.—Hoffman, 1963:271.—Hobbs *et al.*, 1967:52.—Holt, 1954:168; 1955:27; 1963:97; 1964:1; 1967:5; 1969:197; 1973a:84; 1973b:9; 1973c:677; 1973d:21; 1974:66; 1978:472.

*Diagnosis*.—Body terete without specialized projections (other than peristomial tentacles in some species); anterior nephridia opening through common pore on dorsum of segment III; deferent ducts entering ental end of spermiducal gland; prostate arising at commissure of spermiducal gland and ejaculatory duct; penis muscular, protrusible, noneversible; bursa subpyriform to spherical (modified from Hobbs *et al.*, 1967:52).

Key to the Western Species of *Cambarincola*

- 1. Prostate differentiated ..... 2
- Prostate not differentiated ..... 6
- 2. Peristomial tentacles present ..... 3
- Peristomial tentacles absent ..... 5
- 3. Dental formula 5/5 ..... *C. fallax*
- Dental formula 1/1 ..... 4
- 4. Peristomium with 4 dorsal tentacles, 4 lateral lobes, 4 ventral lobes  
..... *C. montanus*
- Peristomium with 4 dorsal tentacles, no lateral lobes, lower lip  
with 1 median indentation ..... *C. macrocephelus*
- 5. Dental formula 1/4 ..... *C. gracilis*
- Dental formula 5/5 ..... *C. serratus*
- 6. Dental formula 3/3 ..... *C. shoshone*
- Dental formula 5/4 ..... 7
- 7. Small worms, jaws unequal in size ..... *C. barbarae*
- Larger worms, jaws of similar size ..... *C. mesochoreus*

*Cambarincola barbarae*, new species

Fig. 1

*Type-specimens*.—Holotype, USNM 54639, and 5 paratypes, PCH 1101, taken on *Procambarus* (*Scapulicambarus*) *clarkii* (Girard, 1852) from (?) irrigation ditch, 3.1 miles east of Solvang, Santa Barbara County, California, 3 July 1960, by Perry C. and Virgie F. Holt.

*Diagnosis*.—Relatively small worms (average length of 5 specimens of type-series 2.2 mm, holotype 1.9 mm); lips entire, separated by broad lateral indentations; no detectable oral papillae; no dorsal ridges; jaws unequal in size, upper more than twice length of lower, with prominent lateral flanges,



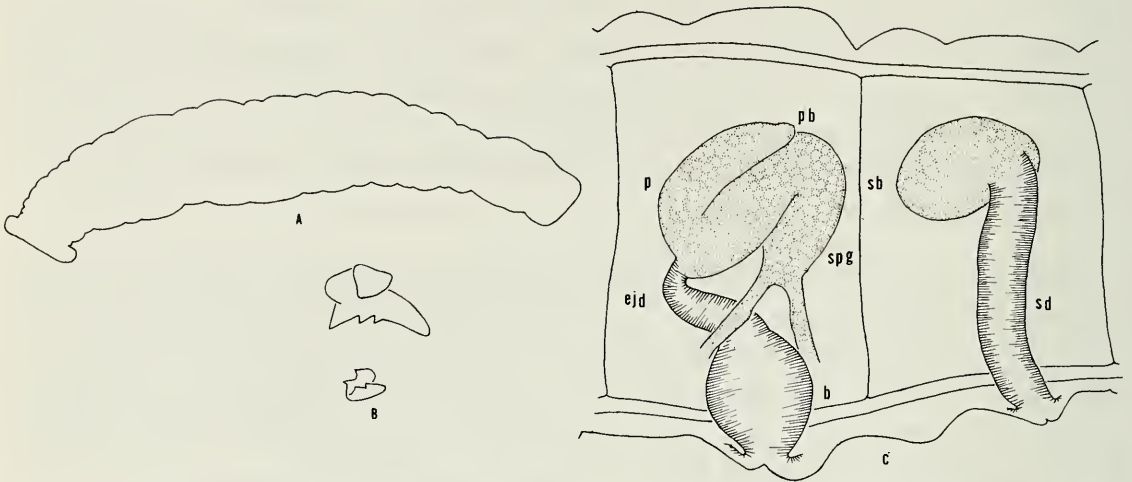


Fig. 1. *Cambarincola barbarae*: A, Lateral view of entire animal; B, Oblique view of jaws; C, Lateral view of reproductive systems. Abbreviations: b, bursa; ejd, ejaculatory duct; p, prostate; pb, prostatic bulb; sb, spermathecal bulb; sd, spermathecal ectal duct; spg, spermiducal gland; vd, vas deferens.

prominent median tooth, dental formula 5/4; bursa small, ovate, about  $\frac{1}{3}$  body diameter; ejaculatory duct of normal proportions; spermiducal gland without deferent lobes, long, sharply reflexed at near its midlength; prostate non-differentiated, ending entally at flexure of spermiducal gland, with small ental bulb; spermatheca greater in total length than body diameter, ectal duct more than twice length of oval bulb, no ental process.

*Etymology*.—For Santa Barbara County, California.

*Description*.—Specimens of *Cambarincola barbarae* are small and externally unprepossessing worms. The dimensions of 5 specimens of the type-series, including the holotype, are as follows: *total length*, 2.2 mm (1.5–3.0 mm); *greatest diameter*, 0.4 mm (0.3–0.5 mm); *head length*, 0.4 mm (0.3–0.4 mm); *head diameter*, 0.2 mm (0.2–0.2 mm); *diameter, segment I*, 0.2 mm (0.2–0.2 mm); *diameter sucker*, 0.2 mm (0.2–0.2 mm).

There are no dorsal ridges, lobes of the lips, or oral papillae. The head is marked, other than the peristomial one, by a shallow external sulcus at the level of the single internal pharyngeal one. The nephridiopore is obscure and the clitellum is inconspicuous.

The jaws are distinctive. The upper is large, more than twice the antero-posterior dimension (length) of the lower and is provided with wide flanges that are deflected ventrad along the lateral margins of the pharynx. It bears a large, prominent tooth at its apex and 2 rather small lateral ones. The lower jaw is of more usual size and configuration: triangular in lateral view, subrectangular *en face* view, with 4 teeth, the median ones somewhat larger than the lateral ones and separated by a prominent depression.

The bursa is relatively small, a little more than  $\frac{1}{3}$  in length that of the



body diameter. Its width is  $\frac{2}{3}$  that of its length; there is no external constriction that demarcates the penial sheath; internally 2 folds project into the bursal atrium.

The spermiducal gland is long, almost  $\frac{2}{3}$  in length that of the body diameter, but bent back upon itself so that the ectal portion is somewhat longer than the ental, and narrower, part. There are no deferent lobes. The prostate is non-differentiated, ends entally at the flexure of the spermiducal gland, and possesses a small obscure prostatic bulb.

The spermatheca is greater in length than the diameter of its segment, with an unusually long ectal duct which comprises more than half the total length of the organ. The bulb is bent backwards, so that it lies alongside the dorsal margin of the gut and is, in shape, elongate ovoid with a thin wall. There is no ental process.

*Variations*.—None of significance. The clitellum is sometimes more prominent than indicated, apparently as a consequence of differences in contraction of the specimen. The spermathecal bulb is in some specimens directed forwards and is, in some cases, globose.

*Affinities*.—The closest relative of *Cambarincola barbarae* is *C. susanae* Holt, 1973c, from Mexico. The two species are of similar size and general facies. The jaws are equally disparate in size with the same dental formula. But the upper jaw of *C. susanae* lacks the lateral flanges of that of *C. barbarae* and the teeth are borne on a raised triangular platform or ridge instead of occupying the more common marginal position as do those of *C. barbarae* (Holt, 1973c:27–28, fig. 12d). The reproductive systems differ in only minor details: the spermiducal gland of *C. susanae* has small deferent lobes, its spermatheca is not so long and the spermathecal bulb is proportionately smaller. For further discussions of the relationships of *C. susanae* see Holt (1973c:15–16; 28).

*Host*.—*Procambarus* (*Scapulicambarus*) *clarkii* (Girard, 1852).

*Distribution*.—The type-locality, and Sonoma County, California.

*Material examined*.—The 6 specimens of the type-series and 5 specimens (PHC 1106) taken on *Procambarus clarkii*, from a pool 4.3 miles southeast of Sebastopol, Sonoma County, California, 7 July 1960.

*Remarks*.—*Cambarincola barbarae* occurs upon an introduced species (Hobbs, 1972:72) which also serves as a host for *C. mesochoreus* Hoffman, 1963, and *C. fallax* Hoffman, 1963. The former species is widespread in the Mississippi Valley and the latter in the Appalachians and were probably introduced with their host. This may be so for *C. barbarae*.

*Cambarincola fallax* Hoffman, 1963

*Cambarincola fallax* Hoffman, 1963:356–359.—Hobbs, Holt, and Walton, 1967:54–55.—Holt, 1969:207; 1973c:681; 1974:69.

*Type-specimens*.—"Holotype and four paratypes, USNM 29945, from *Cambarus longulus* subsp. collected in Maiden Spring Creek, about 1 mile east of Wardell, Tazewell County, Virginia . . . . Additional paratypes from the same collection, PCH 904" (Hoffman, 1963:356).

*Diagnosis*.—"Upper lip with short, slender peristomial tentacles; prosomites (anterior segmental annuli) raised; dental formula 5/5, jaws of same size and shape; prostate with terminal bulb and histologically dissimilar to spermiducal gland" (Hobbs *et al.*, 1967:54).

*Description*.—Hoffman's (1963:356–358) description is extensive and adequate and applies as well to the specimen from California as to the Virginian material.

*Variation*.—See Hoffman (1963:358).

*Affinities*.—Hoffman (1963) did not treat the affinities of *C. fallax* under a distinct heading, but he associated *C. fallax* with *C. philadelphicus* in his discussions and keys (e.g., pp. 340–341). There can be no doubt that the relatives of *C. fallax* are to be sought among the eastern species of the genus with a histologically differentiated prostate that terminates in a clear vacuolated space ("prostatic bulb") and that its peristomial tentacles and 5/5 dental formula are distinctive.

*Host*.—*Procambarus* (*S.*) *clarkii*.

*Distribution*.—The Appalachian uplands and the Coastal Range of California north of San Francisco. The host of the California specimen is an inhabitant of the lower Mississippi River Valley. Associated with *C. fallax* in its only known location in California are another eastern species (*C. mesochoreus*) and a newly described one (*C. barbarae*) that has as its closest relative the widespread Mexican *C. susanae*. This suggests that all the branchiobdellids were introduced from Louisiana or Texas, but *C. fallax* is not at home in lowland waters, has not been found within the eastern range of *P. clarkii*, and is with unlikely associates in California. The example of *Xironogiton instabilis* (Holt, 1974:7, 11), found in both the eastern and western mountains, forecloses any ready assumptions about the origins of the western population of *C. fallax*.

*Material studied*.—One specimen taken on *Procambarus* (*S.*) *clarkii*, from a pool 4.3 miles south of Sebastopol, Sonoma County, California, 7 July 1960.

### *Cambarincola gracilis* Robinson, 1954

Fig. 2

*Cambarincola gracilis* Robinson, 1954:466, figs. 1–4.—Holt and Hoffman, 1959:103.—Hoffman, 1963:369, figs. 77–79.

*Type-specimens*.—Holotype and 10 paratypes, USNM 26110, taken on *Pacifastacus* (*Pacifastacus*) *leniusculus klamathensis* (Stimpson, 1957)



Fig. 2. *Cambarincola gracilis*: A, Lateral view of specimen from Douglas County, Oregon; B, Same of jaws; C, Same of reproductive system.

from creek on campus of Whitman College, Walla Walla, Walla Walla County, Washington, 11 August 1952, by A. G. Rempel; 2 paratypes, USNM 26111, taken on *P. l. klamathensis* from Klamath River, 1 mile west of Ash Creek, Siskiyou County, California, 27 October 1952, by Harold Wolf; 9 paratypes, USNM 26112, taken on *P. (P.) l. trowbridgii* (Stimpson, 1857) from Burdette Creek, Burnaby, British Columbia, 21 May 1942, by G. Clifford Carl (from labels of type-series).

**Diagnosis.**—Small to medium-sized worms (holotype measures 1.8 mm); lips obscurely lobed, lower with median emargination, lateral indentations broad; oral papillae present (not detectable in holotype); prominent dorsal ridges on segments II–VIII, jaws unequal in size, dental formula 1/4; bursa ovate; spermiducal gland stout, without deferent lobes; prostate differentiated, in length about  $\frac{1}{2}$  that of spermiducal gland; spermatheca with long ectal duct, elongate clavate bulb (unexpanded in holotype), without ental process.

**Description.**—The following description is based upon material collected by me and my wife. The holotype has been carefully compared with this material, however, and any discrepancies between it and my material noted.

*Cambarincola gracilis* is composed of small worms, although the paratypes from British Columbia (which are macerated and almost unidentifiable except for the jaws) are longer than the average. Five worms from Myrtle Creek, Douglas County, Oregon, have the following dimensions: *total length*, 1.9 mm (1.6–2.0 mm); *greatest diameter*, 0.4 mm (0.4–0.5 mm); *head length*, 0.4 mm (0.4–0.5 mm); *head diameter*, 0.3 mm (0.2–0.3 mm); *diameter, segment I*, 0.3 mm (0.2–0.3 mm); *diameter, sucker*, 0.3 mm (0.3–0.3 mm).



The upper lip, as noted by Robinson (1954:467) protrudes beyond the lower one. It is subdivided by shallow indentations into 4 indistinct lobes (contra Robinson, 1954:467). The lateral indentations which separate the upper and lower lips are relatively wide and deep. The lower lip is marked by a minute median indentation (not easily seen in most specimens, including the type-series). Several, about 8, oral papillae are present, but not easily detected in some specimens, again including the holotype. The head usually shows no external annular grooves other than the shallow one that delimits the peristomium. There is one pharyngeal sulcus.

Segments I to VII bear dorsal ridges, but that of segment I is low and may lack supernumerary muscles. The anterior nephridiopore is obscure and is not marked by a prominent nephridial vesicle. Robinson (1954) does not mention these ridges and her drawing (Fig. 1) does not clearly show them.

The jaws are dissimilar in size: the upper is approximately twice the length of the lower, has dorsally directed lateral flanges and bears a single large acutely triangular tooth which is in length about  $\frac{1}{2}$  that of the jaw; the lower is of more usual proportions, though the 2 median teeth are prominent. Robinson's (1954:467) comment about the "excavated and somewhat triangular base" of the jaws of *C. macrodonta* applies, but she did not give proper attention to the dorsolateral extensions of the upper jaw of *C. gracilis* and I cannot see, though they may be there, the 2 "weakly developed tubercles" of the upper jaw. Her figs. 2a and 2c of the jaws are almost identical to my independently drawn Fig. 2B. The dental formula is, then,  $1/4$ , since the "tubercles" of the upper jaw are most likely only undulations of its margin. The jaws are relatively light in color, a medium shade of brown, for their size.

Robinson, as Hoffman (1963:369) noted, made a commendable effort to describe and illustrate the reproductive systems, but the literature available to her (she obviously missed my earlier paper, Holt, 1949) was not adequate for a proper description of these organs. What she does say and her illustrations (Robinson, 1954:figures 3 and 4) do not conflict with, and indeed confirm, the following description of the reproductive systems.

The spermiducal gland is slightly flexed at its midlength. It is difficult to measure because of this flexure, but its dorsal border extends to the dorsal border of the gut and its ental end begins near the dorsal, ental end of the bursa. There are no detectable deferent lobes. The prostate is about the size, in both length and diameter, of the spermiducal gland, is differentiated, but lacks an ental bulb.

The bursa presents no unusual features. There is no external constriction of the bursa at the ectal border of the penial sheath which composes about half the organ. There is a prominent atrial fold.

The spermatheca has a long, at least half the total length of the organ,

ectal duct. The spermathecal bulb is clavate. In the specimen illustrated the posterior side is collapsed or wrinkled. The organ, if extended, would equal or exceed in length the diameter of the body. An ental process is lacking.

*Variations.*—An exterior sulcus of the head, at approximately the level of the pharyngeal one, is present as a shallow, obscure groove in some specimens, but not in the holotype. It is possible that Robinson detected lateral teeth in younger specimens, though I have not done so. I suspect that such teeth may be present in the immatures of some species and disappear with growth or wear with age. Oral papillae are undetectable in the holotype, but are so in some other specimens. Robinson's material was fixed in ethyl or isopropyl alcohol and stained with hematoxylin; mine in alcohol-formalin and mounted unstained. Some apparent variations, for instance, the lesser prominence of the dorsal ridges, are undoubtedly due to these differences in treatment.

*Affinities.*—The affinities of *Cambarincola gracilis* are obscure. Robinson (1954:468) compared the species with *Cambarincola macrodontus* Ellis, 1912, the type of the genus, and *C. inversa* Ellis, 1919. The nominal species *inversa* is not a member of the genus *Cambarincola* (Hoffman, 1963:276) and need not be considered here. *Cambarincola macrodontus* does have a short differentiated prostate, but otherwise is quite unlike *C. gracilis*, including the absence of a prostatic bulb in the latter. In fact, *C. gracilis* shares one or another feature with several other species of the genus, but perhaps more with *C. toltecus* Holt, 1973, than any other. Indeed, my description of the latter applies with only two major exceptions, and a few minor ones that are of little significance, to *C. gracilis*. *Cambarincola toltecus* is composed of somewhat larger worms; the holotype is 2.7 mm long, the spermiducal gland is not proportionately as large and the prostate doubtfully has an ental bulb. The only important differences involve the jaws and the spermatheca. The upper jaw of *C. toltecus*, while larger than the lower, is not markedly so and lacks the prominent laterodorsal flanges of *C. gracilis*. The dental formula is the same. The spermathecal bulb of *C. toltecus* is irregularly spatulate and its wall is thick and glandular (Holt, 1973b:29–30). One is tempted to postulate that *C. gracilis* is an advanced member of a stock represented today by the more primitive *C. toltecus* (cf Holt, 1973b:6–7, 30, for a discussion of these points and the affinities of *C. toltecus*).

*Hosts.*—*Pacifastacus* (*Pacifastacus*) *leniusculus klamathensis* (Stimpson, 1857), *P. l. trowbridgii* (Stimpson, 1857), *Procambarus* (*Scapulicambarus*) *clarkii*.

*Distribution.*—*Cambarincola gracilis* is known from southern California northward to southern British Columbia and is second to *C. montanus* in commonness among my collections of western members of the genus. It occurs with *C. barbarae*, *C. mesochoreus*, and *C. montanus* at Solvang,



Santa Barbara County, California. One of these species (*C. mesochoreus*) is a dominant member of the branchiobdellid fauna of its home, the lower plains of the central United States; *C. gracilis* shares dominance with *C. montanus* (it would be interesting to compare the ecological niches of all these species) among the western species of *Cambarinocola*.

*Material examined*.—One specimen (PCH 421) taken on *Pacifastacus* (*P.*) *leniusculus klamathensis* at junction of Steamboat and Umpqua Rivers, Douglas County, Oregon, 12 July 1939, by James W. Bee; 2 specimens (PCH 1101) taken on *Procambarus clarkii* from an (?) irrigation ditch, 3.1 miles east of Solvang, Santa Barbara County, California, 3 July 1960; 4 specimens (PCH 1109) taken on *P. l. klamathensis* from tributary to Rogue River, 5.0 miles north of Rogue Elk, Jackson County, Oregon, 11 July 1960; 12 specimens (PCH 1112) taken on *P. l. klamathensis*, 8.3 miles south of Tiller, Douglas County, Oregon, 11 July 1960; 12 specimens (PCH 1112) taken on *P. l. klamathensis* from North Fork of Umpqua River, at Winchester, Douglas County, Oregon, 11 July 1960; 20 specimens (PCH 1113) taken on *P. l. klamathensis*, 12.6 miles south of Cottage Grove, Douglas County, Oregon, 11 July 1960; 9 specimens (PCH 1117) taken on *P. l. leniusculus* from Mary's River, 4.8 miles east of Blodgett, 12 July 1960; 3 specimens (PCH 1118) taken on *P. l. klamathensis* at Burnt Woods, Lincoln County, Oregon, 12 July 1960; 5 specimens (PCH 1120) taken on *P. l. klamathensis*, 8.6 miles northeast of Toledo, Lincoln County, Oregon, 12 July 1960; 10 specimens (PCH 1121) taken on *P. l. leniusculus* from Siletz River, 24.2 miles southeast of Kernville, Lincoln County, Oregon, 12 July 1960; 6 specimens (PCH 1122) taken on *P. l. leniusculus* from Slick Rock Creek, 5.0 miles southwest of Rose Lodge, Lincoln County, Oregon, 13 July 1960; 2 specimens (PCH 1123) taken on *P. l. klamathensis* from Widow Creek, Lincoln County, Oregon, 13 July 1960; 16 specimens (PCH 1124) taken on *P. l. klamathensis* from South Yamhill River, 1.6 miles west of Valley Junction, Polk County, Oregon; 12 specimens (PCH 1126) taken on *P. l. klamathensis* from Little Pudding Creek, 7.9 miles southwest of Silverton, Marion County, Oregon, 13 July 1960; 9 specimens (PCH 1127) taken on *P. l. klamathensis* from Butte Creek, 6.0 miles northwest of Silverton, Marion-Clackamas County line, 13 July 1960; 2 specimens (PCH 1128) taken on *P. l. klamathensis* from Salmon River, at Brightwood, Clackamas County, Oregon, 13 July 1960; 4 specimens (PCH 1129) taken on *P. l. klamathensis*, 4.8 miles southwest of Skamokawa, Wahkiakum County, Washington, 14 July 1960; 5 specimens (PCH 1130) taken on *P. l. klamathensis* from Gray's River, 21.0 miles east of Gray's River, Wahkiakum County, Washington, 14 July 1960; 5 specimens (PCH 1132) taken on *P. l. klamathensis* from West Fork Hoquiam River, 14.5 miles south of Humptulips, Gray's Harbor County, Washington, 16 July 1960; 1 specimen (PCH 1134) taken on *P. l. leniusculus*, 3.0 miles south of Amanda Park, Gray's Harbor



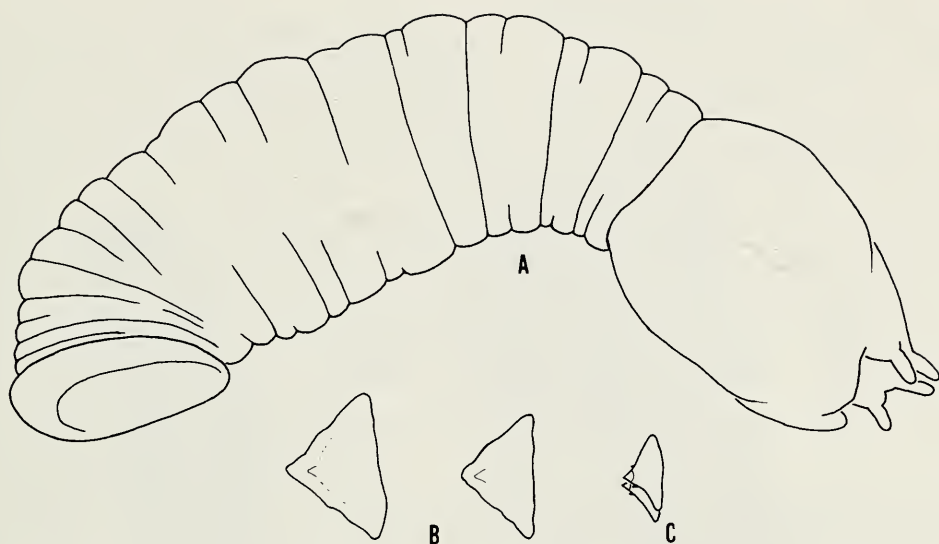


Fig. 3. *Cambarincola macrocephelus*: A, Lateral view of specimen from Gooding County, Idaho; B, En face view of jaws; C, Dorsal view of jaws of younger specimen in place.

County, Washington, 16 July 1960; 4 specimens (PCH 1137) taken from Mill Creek at Forks, Clallam County, Washington, 16 July 1960; 3 specimens (PCH 1142) taken from (?) irrigation ditch, 7.2 miles east of Ellensburg, Kittitas County, Washington, 18 July 1960. (See Robinson, 1954:467 for additional locality records.)

*Cambarincola macrocephalus* Goodnight, 1943

Figs. 3–4

*Cambarincola macrocephala* Goodnight, 1943:100–101, figs. 1–2.—Holt, 1969:209; 1963b:10.

*Cambarincola macrocephala*.—Holt and Hoffman, 1959:103.—Hoffman, 1963:312–314, Figs. 14–17, 19.

*Cambarincola macrocephelus*, Holt, 1973b:10.

*Type-specimen*.—USNM 20598, taken on *Pacifastacus* (*Hobbsastacus*) *gambelli* (Girard, 1852) from Polecat Creek, Teton County, Wyoming, 16 August 1941, by Robert C. Brown (Goodnight, 1943).

*Diagnosis*.—Large worms (average about 5.0 mm); upper lip bearing 4 tentacles, lower with shallow median emargination; oral papillae absent; head large, approaching  $\frac{1}{3}$  entire body in size; dorsal ridges absent; jaws large, triangular, subequal in size, dental formula 1/1 (? 3/3); bursa subglobose; spermiducal gland long, slender, extending to dorsal border of coelom, with prominent deferent lobes; prostate differentiated, without prostactic bulb, equal in length to, slightly greater in diameter than, spermiducal gland; spermatheca long, slender, narrowing entally.

*Description*.—Goodnight's (1943) original description is inadequate. But

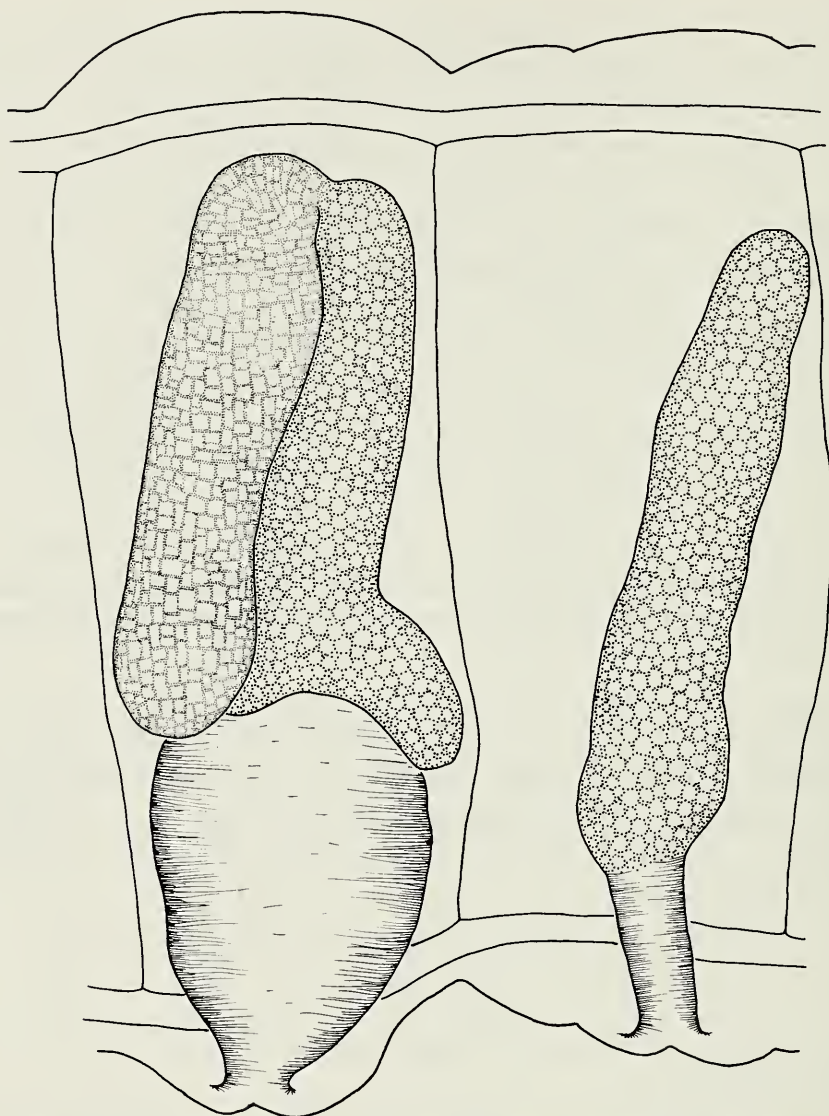


Fig. 4. *Cambarincola macrocephalus*: Lateral view of reproductive systems of specimen from Gooding County, Idaho.

the size, tentaculation of the upper lip and the shape of the jaws of his holotype are, on the basis of my knowledge of the branchiobdellids of the area, diagnostic. Hoffman also examined the holotype and concluded that the material upon which the following redescription is based is conspecific with Goodnight's. But Hoffman (1963:312–314) worked under limitations that no longer exist and his description of this material requires emendment.

Members of *Cambarincola macrocephalus* are large worms, larger than Goodnight (1943:100) suggests: preserved mature worms are about 5.0 mm long. Two fully mature and 3 subadult (some reproductive structures present, but not fully developed) worms which comprise the total unsectioned material in my collection have the following dimensions: *total length*, 3.7

mm (2.6–5.6 mm); *greatest diameter*, 0.9 mm (9.5–1.4 mm); *head length*, 1.1 mm (0.8–1.6 mm); *head diameter*, 0.7 mm (0.5–1.0 mm); *diameter, segment I*, 0.6 mm (0.4–1.0); *diameter, sucker*, 0.6 mm (0.4–1.0).

The upper lip bears 4 tentacles delimited by slight constrictions basally; a shallow, median indentation is characteristic of the lower. Oral papillae are not detectable. The peristomium is obscurely marked by a very shallow sulcus (contra Hoffman, 1963:313) and tapers towards its labial border. Other external sulci of the head are absent; 2 internal pharyngeal ones are distinct. The head is most distinctive in its proportions: almost  $\frac{1}{3}$  of the length of the total body, greater in diameter than either segment I or the sucker and noticeably pyriform, it is, for the size of the worm, a proportionately huge mass of muscles.

The anterior annuli of the body segments, though apparently lacking supernumerary muscles, are slightly greater in diameter than the posterior ones, all are greater in diameter than their antero-posterior dimensions. Hoffman (1963:113–114) states that the anterior segments of the holotype are tripartite and illustrates this feature: this is not true of the Idaho material and I suspect that he is in error on this point. The matter is worthy of note, since the anterior annuli of anterior segments of some species are marked by superficial annular indentations. At first glance those of *C. macrocephalus* are, but this is an optical illusion created by seeing the segmental annuli of the worms on both sides simultaneously. The sucker is slightly greater in diameter than segment I. The anterior nephridiopore is obscure.

The jaws are large, though not disproportionately so for the size of the animal, medium dark brown and triangular in both lateral and *en face* aspects. Hoffman (1963:313) stated that the dental formula is 3/3; Goodnight (1943:100) that the jaws lack teeth. My interpretation is that the jaws, subequal in size and shape, bear a single tooth at their apex, though there appear to be lateral teeth on the jaws of younger animals.

The bursa is large, somewhat less than the diameter of its segment in length. If the ectal “outlet duct” of the bursa is, as it should be, considered a part of its structure, the bursa is subcylindrical rather than “subglobose” (Hoffman, 1963:113) and the penial sheath composes approximately  $\frac{1}{2}$  of the organ.

The spermiducal gland runs ventro-dorsad from border to border of the coelom and is rather slender, somewhat greater in diameter than the prostate. It is of the usual histological structure and bears prominent deferent lobes (Fig. 4). Hoffman (1963:313) describes the prostate as histologically similar to the spermiducal gland (non-differentiated). This is not so. The prostate is differentiated, but lacks an ental bulb. At the time he wrote, all the members of the genus we knew with differentiated prostates also possessed an ental bulb, hence the error.

The spermatheca is long, slender, reaches almost to the dorsal border of



the coelom and is greater in diameter immediately entad to the junction of spermathecal bulb and ectal duct. The bulb is slender, irregularly indented or "twisted," tapers to its ental end, lacks an ental process, appears unusually thick-walled in the animal mounted entire, but serially sectioned material reveals the usual histology.

*Variations*.—None other than the usual ones related to size.

*Affinities*.—Although several species of *Cambarincola* have been recognized since Hoffman wrote on the genus, the only pertinent consideration is the possible relationship of *C. macrocephelus* and *C. montanus* (Goodnight, 1940). The latter seems to be composed of somewhat larger worms (average length, 5.8 mm) with 4 dorsal tentacles and 2 median and 4 ventral lobes of the peristomium; an enormous prostate; a spermatheca with a long ectal duct and globose bulb. It is western in distribution, though not known from the upper Snake River drainage. Otherwise Hoffman's designation of *C. holti* Hoffman, 1963, from Kentucky, "which differs in its smaller size, particularly that of the head, and longer glandular organs of the male reproductive system," as the closest relative, in the sense of structural similarities, still applies.

*Host*.—*Pacifastacus (Hobbsastacus) gambelli* (Girard, 1852).

*Distribution*.—The upper reaches of the Snake River drainage in Idaho and Wyoming.

*Material examined*.—Two mature specimens, 3 immature ones, mounted entire, one serially sectioned animal (PCH 785) taken on *Pacifastacus gambelli* from Riley Creek, Gooding County, Idaho, 14 July 1958. This is the same material upon which Hoffman's (1963) account is based. Hoffman worked in my laboratory under my supervision and the corrections of and additions to his description are required by the advances I have made in my understanding of the branchiobdellids in the intervening years. I have no doubt that this material is conspecific with Goodnight's poorly preserved and mounted holotype. In addition, 5 specimens, poorly preserved, taken on *P. gambelli* from the South Fork of the Snake River, by P. Andriano, 28 August 1952, are tentatively assigned to *C. macrocephelus*.

*Nomenclatural note*.—The spelling of this species has varied (Holt and Hoffman, 1959:103; Hoffman, 1963:312–314; Holt, 1969:209; Holt, 1973b:10) because of my uncertainty as to whether Goodnight's (1943:100–101) original spelling as *macrocephela* should be regarded as an emendable error. Authorities who have advised us differ (See Article 32 (a) (iii) of the International Code of Zoological Nomenclature). In view of other errors in Goodnight's writings and his reference to "head large" in his diagnosis of the species, I herein, nonetheless, revert to my original view that the original spelling of the species' name was an egregious and correctible error. Thus, in accordance with Article 30 (a), (i) (2) of the International Code of Zoological

Nomenclature, the spelling becomes “macrocephalus” (see Holt, 1973b: 9–10). I am grateful to Dr. George Steyskal for suggesting this solution of what had become for me a vexing problem.

*Cambarincola mesochoreus* Hoffman, 1963

*Cambarincola vitrea* (in part).—Ellis, 1919:257–258.

*Cambarincola macrodonta* (in part).—Ellis, 1919:257.

*Cambarincola mesochorea* Hoffman, 1963:307–311.—Holt, 1969:209.

*Cambarincola mesochoreus*.—Holt, 1963b:10.

*Type-specimens*.—“Holotype and four paratypes, USNM 29939, from *Orconectes* sp. collected . . . 1.5 miles east of Adyville, Perry County, Indiana, by P. C. Holt, July 28 1958 . . . Additional paratypes . . . PCH 815” (Hoffman, 1963:307, 309).

*Diagnosis*.—Relatively large worms (average length about 3.5 mm; lips entire; no detectable oral papillae; no dorsal ridges; jaws subequal in size, dental formula 5/4; bursa small, subspherical; spermiducal gland slender, recurved; without deferent lobes; prostate equal to or greater in diameter, greater in length than spermiducal gland, non-differentiated, no ental bulb; spermatheca slender, elongate, subfusiform, with ental process (modified from Hoffman, 1963:307–308).

*Description*.—Hoffman (1963:307–308) presents an adequate description.

*Variation*.—None noted, except for the usual variations in size and relative positions of reproductive organs.

*Affinities*.—Hoffman (1963:306–307) regarded *Cambarincola restans* Hoffman, 1963, and *C. mesochoreus* as closely related on the basis of similarities between their reproductive systems. The head of *C. restans* is disproportionately large and there are deferent lobes of the spermiducal gland.

*Host*.—*Procambarus* (*Scapulicambarus*) *clarkii*.

*Distribution*.—As questionably noted for *C. barbarae* and more certainly for *C. fallax*, *C. mesochoreus* is an introduced species, known in California from Santa Barbara, Merced, and Sonoma Counties.

*Material examined*.—Four specimens (PCH 1101) taken on *Procambarus clarkii*, 31 miles east of Solvang, Santa Barbara County, California, 3 July 1960; 27 specimens (PCH 1102) taken on *P. clarkii* from irrigation ditch, 2.9 miles west of Los Banos, Merced County, California, 5 July 1960; 8 specimens (PCH 1103) taken on *P. clarkii* from irrigation ditch, 2.0 miles east of Los Banos, Merced County, California; 15 specimens (PCH 1104) taken on *P. clarkii* from Deadman’s Creek, 7.1 miles west of Merced, Merced County, California, 5 July 1960; 10 specimens (PCH 1106) taken on *P. clarkii*, 4.3 miles southeast of Sebastopol, Sonoma County, California, 7 July 1960.



*Cambarincola montanus* (Goodnight)

*Triannulata montana* Goodnight, 1940:56–57; Liang, 1963:570; Holt, 1969:195.

*Cambarincola montanus*.—Holt, 1974a:67–70.

*Type-specimen*.—Holotype, USNM 2056, from the Kalmi River, Washington, on *Pacifastacus* species.

*Diagnosis*.—Large worms, about 6.0 mm in length; lips with 4 dorsal tentacles, 4 prominent lateral, 4 prominent ventral lobes; no oral papillae; no dorsal ridges; jaws massive, dental formula 1/2 (5/5 in immature forms); bursa subpyriform, about  $\frac{1}{3}$  segmental diameter in length; spermiducal gland proportionately small, about  $\frac{1}{3}$  segmental diameter in length, with anterior deferent lobe; prostate subequal to spermiducal gland in length,  $1\frac{1}{2}$  times in diameter that of spermiducal gland, no ental bulb, histologically differentiated; spermatheca about  $\frac{1}{2}$  segmental diameter in length, ectal duct long, bulb globose, no ental process.

A previous treatment of *C. montanus* (Holt, 1974a:67–70) was based upon some of the material included in this study. Little new can be added herein, except to note 16 additional localities from which specimens have been studied.

*Distribution*.—Goodnight (1940:57) reported *C. montanus* from “North Fork of the Clearwater River near Bovril, Idaho.” [His designation of some of these specimens as paratypes is no longer relevant to such studies as these, since he long ago “lost” his collections (pers. comm.)]. But it is unlikely he was mistaken, so *C. montanus* is known from southern California to northwest Washington and eastward into Idaho. The species is represented in more of my collections (27) than any other western member of the genus.

*Material examined*.—Five specimens (PCH 421) taken on *Pacifastacus klamathensis* Stimpson at the junction of the Steamboat and Umpqua Rivers, Douglas County, Oregon, 12 July 1939, by James W. Bee; 9 specimens (PCH 921) taken on *P. klamathensis* from Purdy Creek, 6 miles north of Gig Harbor, Pierce County, Washington, 26 June and 13 July 1959, by Darwin E. Norby; 3 specimens (PCH 1101) taken on *Procambarus* (*S.*) *clarkii* 3.1 miles east of Solvang, Santa Barbara County, California, 3 July 1960; 1 specimen (PCH 1117) taken on *Pacifastacus leniusculus* from Mary’s River, 4.8 miles east of Blodgett, Benton County, Oregon, 12 July 1960; 2 specimens (PCH 1118) taken on *P. klamathensis* from small stream at U.S. Post Office in Burnt Woods, Lincoln County, Oregon, 12 July 1960; 2 specimens (PCH 1120) taken on *P. klamathensis* from small stream, 8.6 miles northeast of Toledo, Lincoln County, Oregon, 12 July 1960; 3 specimens (PCH 1121) taken on *P. leniusculus* from the Siletz River, 24.3 miles southeast of Kernville, Lincoln County, Oregon, 12 July 1960; 3 specimens



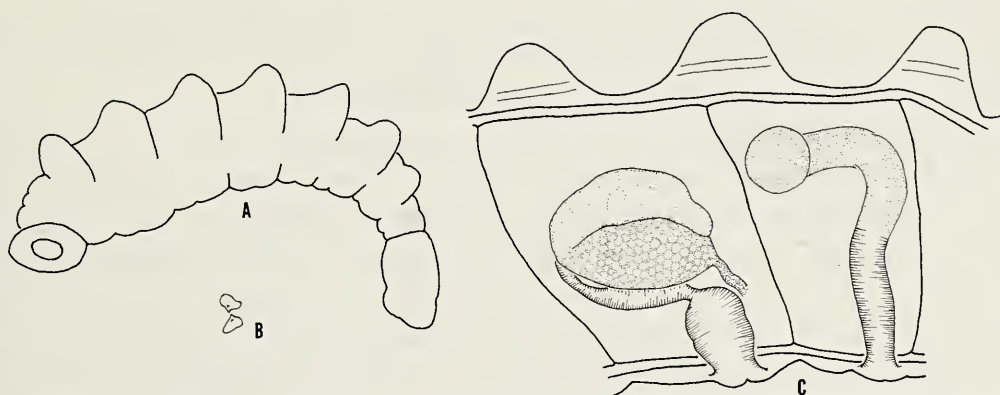


Fig. 5. *Cambarincola serratus*, new species: A, Lateral view of holotype; B, same of jaws; C, same of reproductive systems.

(PCH 1122) taken on *P. leniusculus* from Slick Rock Creek, 5.0 miles southwest of Rose Lodge, Tillamook County line, Oregon, 13 July 1960; 3 specimens (PCH 1125) taken on *P. klamathensis* from Salt Creek, 3.5 miles northwest of Dallas, Polk County, Oregon; 13 specimens (PCH 1126) taken on *P. klamathensis* from Little Pudding Creek, 7.9 miles southwest of Silverton, Marion County, Oregon; 1 specimen (PCH 1139) taken on *P. klamathensis* from a small stream at U.S. Highway 830, 4.8 miles southeast of Skamokawa, 14 July 1960; 4 specimens (PCH 1132) taken on *P. klamathensis* from West Fork of Hoquiam River, 14.5 miles south of Humptulips, Grays Harbor County, Washington, 16 July 1960; 1 specimen (PCH 1136) taken from Nolan Creek, 21.5 miles south of Forks, Jefferson County, Washington, 16 July 1960; 2 specimens (PCH 1139) taken from Minter Creek, 3.8 miles west of Wauna, Pierce County, Washington, 17 July 1960; 2 specimens (PCH 1142) taken from a warm pool (? irrigation ditch) 7.2 miles east of Ellensburg, Kittitas County, Washington, 18 July 1960.

*Cambarincola serratus*, new species

Fig. 5

*Type-specimens*.—Holotype, USNM 54638; 3 paratypes, PCH 785, taken on *Pacifastacus* (*Hobbsastacus*) *connectens* (Faxon, 1914) from Idaho State Fish Hatchery, Riley Creek, Gooding County, Idaho, 14 July 1958; 2 paratypes, PCH 784, taken on *P. connectens* from spring tributary to Snake River, Hagerman, Gooding County, Idaho, 14 July 1958.

*Diagnosis*.—Small worms (holotype 1.7 mm in length); lips entire; oral papillae present; dorsal ridges on segments II–VIII prominent; jaws light yellow; triangular in lateral view, quadrangular *en face* view, dental formula 5/5; bursa small, about  $\frac{1}{3}$  body diameter in length; spermiducal gland short, subcylindrical; prostate subequal in length, slightly shorter than sper-

miducal gland, composed of highly vacuolated cells; spermatheca with long ectal duct, cylindrical bulb expanded entally.

*Etymology*.—From Latin *serratus*, saw-like.

*Description*.—*Cambarincola serratus* is composed of some of the smallest worms of the genus. The holotype has the following dimensions: *total length*, 1.7 mm; *greatest diameter*, 0.3 mm; *head length*, 0.3 mm; *head diameter*, 0.2 mm; *diameter, segment I*, 0.2 mm; *diameter, sucker*, 0.2 mm. The holotype and 4 paratypes have the following average dimensions: *total length*, 1.6 mm (1.3–1.7 mm); *greatest diameter*, 0.4 mm (0.3–0.5 mm); *head length*, 0.3 mm (0.2–0.3 mm); *head diameter*, 0.2 mm (0.1–0.2 mm); *diameter, segment I*, 0.1 mm (0.1–0.2 mm), *diameter, sucker*, 0.2 mm (0.2–0.2 mm).

The lips are entire; an indeterminate number of oral papillae are present. External sulci of the head are confined to that delimiting the peristomium. There is one internal pharyngeal sulcus. The dorsal ridges of segments II–VIII are very pronounced and serve immediately to identify the species.

The jaws are proportionately small; about  $\frac{1}{7}$  to  $\frac{1}{6}$  the diameter of the head in width. The teeth are small and blunt, very difficult to count in the usual type of preparations and are uniform in length, except for a slightly greater size of the median ones.

The spermiducal gland is small, about twice its diameter and less than half that of the body in length. It narrows slightly as it approaches its function with the ejaculatory duct and normally lies horizontally within its segment. There are no detectable deferent lobes.

The prostate is subequal to the spermiducal gland in length and somewhat less than the latter in diameter. Its ental portion is markedly narrowed, but no prostatic bulb is evident. The organ is composed of very large cells that appear to be filled with a clear fluid and are highly vacuolated. The prostate is often difficult to see in whole mounts.

The bursa is cylindrical, twice as long as thick and about  $\frac{2}{3}$  the diameter of the segment in length. Penial sheath and atrial portions of the bursa are subequal.

The spermatheca is composed of a very long ectal duct, a median thick-walled section that contains spermatozoa and a long cylindrical, thin-walled spermathecal bulb that runs dorsally to the gut posteriorad for more than the length of the segment. There is no ental process. The total length of the organ cannot be determined in whole mounts, but must exceed twice the diameter of segment V.

*Variations*.—None have been noticed, except the usual ones of slight differences of size and the positions of the reproductive organs in their respective segments.

*Affinities*.—The unique combination of the exaggeratedly raised dorsal ridges, the highly vacuolated prostate and the extremely long spermatheca

sharply separates *C. serratus* from all of its congeners. In its general facies, one is immediately reminded of species of *Pterodrilus*. The latter genus is, indeed, considered a specialized branch of small worms derived from a "primitive" stock of the genus *Cambarincola* (Holt, 1968b:3–5) and *C. serratus* may be considered a western vicariant of an eastern species of *Pterodrilus*. The similarity extends to the diet of each: diatoms are a prominent part of the food of the species of *Pterodrilus* as of *C. serratus*. None of the known species of *Cambarincola* closely resembles *C. serratus* and for now it must be considered a disjunct representative of those members of the genus with differentiated prostates: the "Philadelphica Section" of Hoffman (1963).

*Host*.—*Pacifastacus* (*Hobbsastacus*) *connectens* (Faxon, 1914).

*Distribution*.—Tributaries of the Snake River, Gooding County, Idaho.

*Material examined*.—The type-series.

#### *Cambarincola shoshone* Hoffman

*Cambarincola shoshone* Hoffman, 1963:319–320.—Holt, 1969:209.

*Type-specimens*.—"Holotype and three paratypes, USNM 29941, from *Pacifastacus gambelii connectans* (= *P. (H.) connectens*) collected in Riley Creek in the Idaho Fish Hatchery near Hagerman, Gooding County, Idaho, by Perry C. (and Virgie F.) Holt, 14 July 1958. Topotypes from the same collection, PCH 785" (Hoffman, 1963:319).

*Diagnosis*.—Small worms, somewhat less than 2.0 mm in length; lips entire; no dorsal ridges; jaws small, dental formula 3/3; bursa small, about  $\frac{1}{3}$  body diameter in length; spermiducal gland larger than bursa with deferent lobes; prostate slender, shorter, about  $\frac{1}{3}$  spermiducal gland in length, nondifferentiated, no ental bulb; spermatheca with ental bulb (emended from Hoffman, 1963:319–320).

*Remarks*.—This species has not appeared in any subsequent collections, therefore nothing can be added to Hoffman's treatment. He adequately described and illustrated the material and considered *Cambarincola branchiophilus* Holt, 1954, as its closest relative, a reasonable supposition at the time, but the sad fact is that until many new species are named and a long and intensive effort is devoted to monographing the genus, no speculation about the affinities of any species of the genus *Cambarincola* is entirely plausible.

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### Literature Cited

- Altman, Luther C. 1936. Oligochaeta of Washington.—University of Washington Publications in Biology 4(1):1–137.
- Ellis, Max M. 1912. A new discodrilid worm from Colorado.—Proceedings of the United States National Museum 42(1912):481–486.
- . 1919. The branchiobdellid worms in the collections of the United States National Museum, with descriptions of new genera and new species.—Proceedings of the United States National Museum 55(2267):241–265, pls. 10–13.
- Goodnight, Clarence J. 1939. Geographical distribution of North American branchiobdellids.—Journal of Parasitology 25:11.
- . 1940a. New records of branchiobdellids (Oligochaeta) and their crayfish hosts.—Report of the Reelfoot Lake Biological Station 4:70–71.
- . 1940b. The Branchiobdellidae (Oligochaeta) of North American crayfishes.—Illinois Biological Monographs 17(3):1–75.
- . 1943. Report on a collection of branchiobdellids.—Journal of Parasitology 29(2):100–102.
- Hall, Maurice C. 1914. Description of a new genus and a new species of the discodrilid worms.—Proceedings of the United States National Museum 48(2071):187–193.
- Hobbs, Horton H., Jr. 1972. A checklist of the North and Middle American crayfishes.—Smithsonian Contributions to Zoology 166:i–iii, 1–161.
- , Perry C. Holt, and Margaret Walton. 1967. The crayfishes and their epizootic associates of the Mountain Lake, Virginia, Region.—Proceedings of the United States National Museum 123(3602):1–84.
- Hoffman, Richard L. 1963. A revision of the North American annelid worms of the genus *Cambarincola* (Oligochaeta: Branchiobdellidae).—Proceedings of the United States National Museum 114(3470):271–371.
- Holt, Perry C. 1949. A comparative study of the reproductive systems of *Xironogiton instabilis instabilis* (Moore) and *Cambarincola philadelphica* (Leidy) (Annelida, Oligochaeta, Branchiobdellidae).—Journal of Morphology 84(3):535–572.
- . 1954. A new branchiobdellid of the genus *Cambarincola* (Oligochaeta, Branchiobdellidae) from Virginia.—Virginia Journal of Science 5(3) (New Series):168–172.
- . 1955. A new branchiobdellid of the genus *Cambarincola* Ellis, 1912 (Oligochaeta, Branchiobdellidae) from Kentucky.—Journal of the Tennessee Academy of Science 30(1):27–31.
- . 1963. A new branchiobdellid (Branchiobdellidae: *Cambarincola*).—Journal of the Tennessee Academy of Science 38(3):97–100.
- . 1964. A new branchiobdellid (Annelida) from Costa Rica.—Tulane Studies in Zoology 12(1):1–4.
- . 1968a. The Branchiobdellida: epizootic annelids.—The Biologist 50(3–4):79–94.
- . 1968b. New genera and species of branchiobdellid worms (Annelida: Clitellata).—Proceedings of the Biological Society of Washington 81:291–318.
- . 1969. The relationships of the branchiobdellid fauna of the southern Appalachians. In Holt, Perry C. (ed.). The distributional history of the biota of the southern Appalachians. Part 1: Invertebrates.—Research Division Monographs 1, Virginia Polytechnic Institute:191–219.

- . 1973a. Epigeal branchiobdellids (Annelida: Clitellata) from Florida.—Proceedings of the Biological Society of Washington 86(7):79–104.
- . 1973b. A summary of the branchiobdellid (Annelida: Clitellata) fauna of Mesoamerica.—Smithsonian Contributions to Zoology 142:i–iii, 1–40.
- . 1973c. An emended description of *Cambarincola meyeri* Goodnight (Clitellata: Branchiobdellida).—Transactions of the American Microscopical Society 92(4):677–682.
- . 1973d. Branchiobdellids (Annelida: Clitellata) from some eastern North American caves, with descriptions of new species of the genus *Cambarincola*.—International Journal of Speleology 5(1973):219–256.
- . 1974a. An emendation of the genus *Triannulata* Goodnight, 1940, with the assignment of *Triannulata montana* to *Cambarincola* Ellis, 1912 (Clitellata: Branchiobdellida).—Proceedings of the Biological Society of Washington 87(8):57–72.
- . 1974b. The genus *Xironogiton* Ellis, 1919 (Clitellata: Branchiobdellida).—Virginia Journal of Science 25(1):5–19.
- , and Richard L. Hoffman. 1959. An emended description of *Cambarincola macrodonta* Ellis, with remarks on the diagnostic characters of the genus.—Journal of the Tennessee Academy of Science 34(2):97–104.
- Liang, Yan-Lin. 1963. Studies on the aquatic Oligochaeta of China. I. Descriptions of new naids and branchiobdellids.—Acta Zoologica Sinica 15(4):560–570.
- Leidy, Joseph. 1851. Contributions to Helminthology.—Proceedings of the Academy of Natural Science, Philadelphia 5:205–209.
- Moore, J. Percy. 1894. On some leech-like parasites of American crayfishes.—Proceedings of the Academy of Natural Science, Philadelphia 1893:419–428, pl. 12.
- Robinson, Dorothy A. 1954. *Cambarincola gracilis*, sp. nov., a branchiobdellid oligochaete commensal on western crayfishes.—Journal of Parasitology 40:466–469.
- Pierantoni, Umberto. 1912. Monografia dei Discodrillidae.—Annuario del Museo Zoologico della Università di Napoli, new series 3(24):1–28, figs. 1–20, pl. 5.
- Stephenson, J. 1930. The Oligochaeta. 978 pp., 242 figs.—Oxford: Oxford University Press.
- Yamaguchi, Hideji. 1932. A new species of *Cambarincola*, with remarks on the spermatid vesicles of some worms.—Proceedings of the Imperial Academy of Japan 8(9):454–455.
- . 1933. Description of a new branchiobdellid, *Cambarincola okadai*, n. sp., parasitic on American crayfish transferred into a Japanese lake.—Proceedings of the Imperial Academy of Japan 9(4):191–193.
- . 1934. Studies on Japanese Branchiobdellidae with some revisions on the classification.—Journal of the Faculty of Science, Hokaido Imperial University, series 6, 3(3):177–219, pls. 12–13.

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